PRECISION AC-DC VOLTMETER

Model AC-210B-1/BR-1

SERIAL 9270018

CALIBRATION STANDARDS CORPORATION

1031 Westminster Avenue
Alhambra, California

Telephone - 213-283-8156
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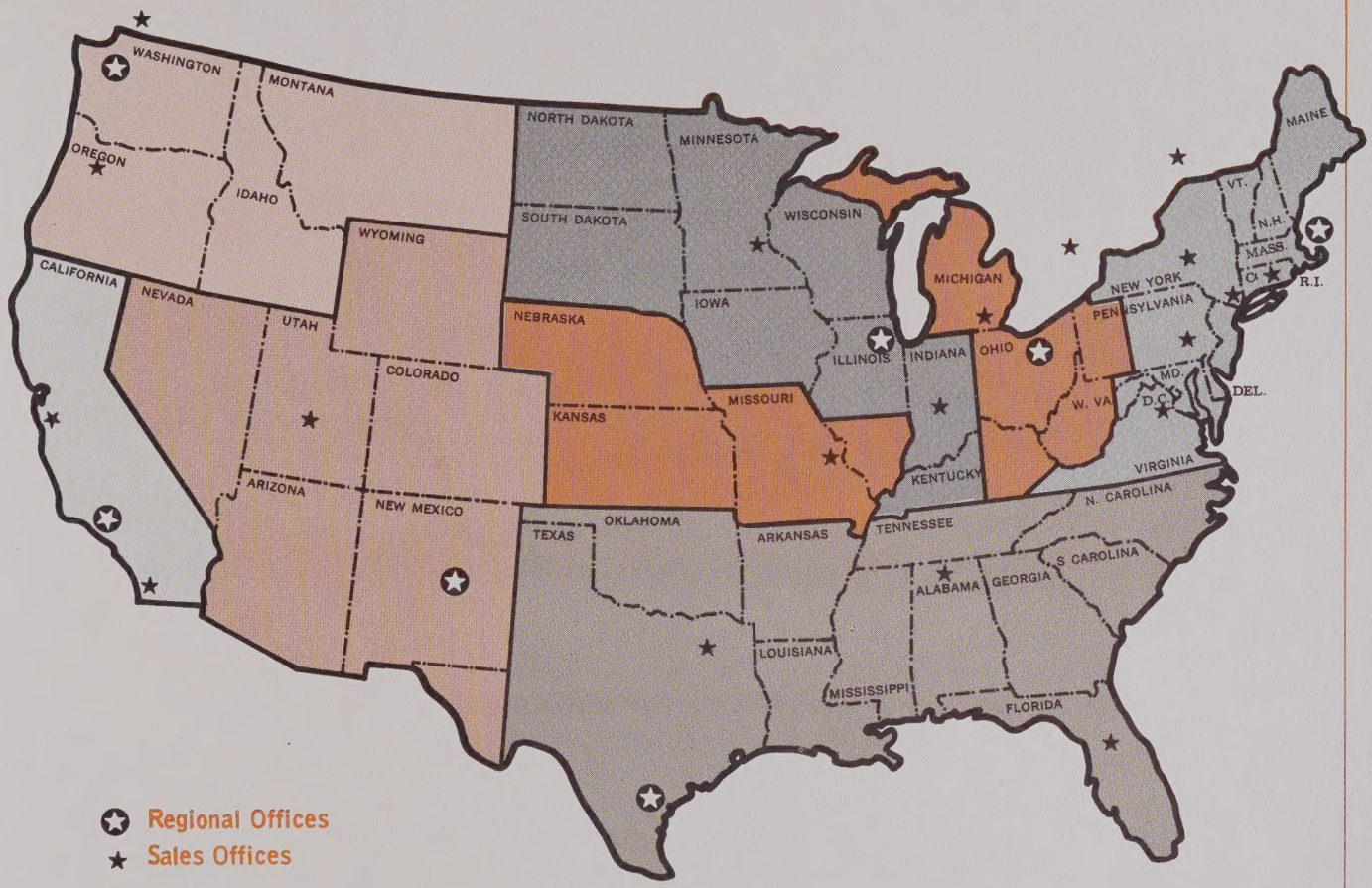

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IMPORTANT

FOR OPTIMUM RESULTS, PLEASE READ THE INSTRUCTION MANUAL CAREFULLY.

This instrument you have purchased represents a major advance in the field of transistorized precision test equipment.

Since this instrument incorporates the latest engineering techniques and design, it is imperative that you become familiar with the proper operating procedure.

Meter zeroing adjustment is performed at the factory. Normally no further adjustment is required. Should adjustment be necessary, the meter may be zeroed by the mechanical adjustment screw on the meter itself while the instrument is operating.

OPERATING INSTRUCTIONS

DC MODE

1. The line cord should be plugged into a 117-volt 60-cycle power source. (220-volt if indicated).
2. Turn the null selector to TVM position and power switch on. Let the instrument warm up for approximately 10 minutes.
3. Check mechanical zero of meter. If necessary, adjust to zero by means of the screw in the center of the meter case.
4. Turn the range selector knob to the desired range. Connect the voltage to be measured to the terminal posts. Either positive or negative may be grounded to the common terminal. When operating with the polarity switch in the positive mode, the negative terminal is generally grounded to the case or left floating and in the negative mode, the reverse.
5. The voltage now indicated on the meter is accurate within 4%. If the meter needle swings to the left, turn the polarity switch to the NEG position.
6. Position first two readout dials to the approximate TVM voltage reading. Advance the null selector knob to the 1-volt position. Continue to adjust the readout while increasing the null sensitivity. You are now zeroing in on null.
7. When, by the procedure above, the null selector is at full sensitivity (1 mv) and the meter reading zero, the voltage read from the dials is accurate to better than the rated accuracy of the instrument. Because the sensitivity of your instrument in the 1 mv null position is higher than the stability of many sources, you may not get a reading of zero if the voltage you are measuring is not constant and is fluctuating.

OPERATING INSTRUCTIONS (Continued)

READING EXCURSIONS ABOUT A NOMINAL VOLTAGE

8. To read excursions of voltage about a nominal value, set the readout dials to the nominal value. Excursions may be observed directly on the meter on any of the four null ranges. A right hand deflection of the meter indicates the voltage has increased above the nominal value by the amount indicated on the meter. For voltages read on the 10-volt range and below, use null sensitivity selector as marked. On the 100-volt ranges, the null sensitivity selector value must be multiplied by a factor of 10. On the 1000-volt range the null sensitivity selector value must be multiplied by a factor of 100.

DIRECT MEASUREMENTS OF 10 VOLTS AND ABOVE

9. With the range selector in the 10-volt position, use full scale values as marked on the meter. When range selector is in the 100-volt position, multiply the meter reading by 10. On the 1000-volt range, multiply the reading by 100.

VARIATIONS IN NULL DETECTOR SENSITIVITY

10. Due to the circuit design on the 100-volt range, the null detector will have reduced sensitivity on the 1 mv and 10 mv positions. This is due to a high internal source impedance of the high voltage input divider. The sensitivity is about 50% less in the 1 mv null position and about 15% less on the 10 mv position. Only a very slight loss of sensitivity is noticed on the other null ranges. When the range selector is in the 1000-volt position, a 10% loss of sensitivity will be noticed in the 1 mv position.

OPERATING INSTRUCTIONS (Continued)

The other null ranges will have only a very slight loss of sensitivity.

MEASUREMENTS BELOW 1 VOLT IN DIFFERENTIAL MODE

11. When making measurements below 1 volt, turn Range Selector switch to the 1-volt position. Set null selector to the 1 mv position. Set all readout dials to zero and short positive and negative input terminals together.

12. Now set the mechanical meter adjustment to zero. This will cancel out error due to zero offset between the 1 millivolt range and the VTVM range. Remove short across terminals and proceed with the reading of voltage per paragraphs 4, 5, 6, and 7.

"POS" AND "NEG" POLARITY

13. This instrument is capable of measuring both positive and negative voltages without reversing the input connections, by setting the polarity switch in the correct position.

Under some conditions the reading in the "NEG" position may differ from the "POS" position. This difference is very small in comparison to the rated accuracy of the instrument. Since the instrument is calibrated in the "POS" position, the best accuracy will result when the polarity switch is in this position.

OPERATING INSTRUCTIONS (Continued)

RECORDER OUTPUT

14. Two sets of output terminals are located on the rear of the voltmeter. One set is the recorder output and the other is the Kelvin-Varley output. The output voltage of the recorder output terminals is ±25 mv for a full scale deflection. The output impedance is approximately 200Ω. Any recorder may be used so long as the leakage resistance to the line or ground is better than 10,000 megohms.

When using high speed recorders, it may be necessary to install a filter between the output terminals of the voltmeter and the input of the recorder. The output signal of the voltmeter will have the demodulated chopper signal and must be filtered out. Generally a three-stage RC filter using 33K resistors and 1 mfd capacitors will be sufficient.

KELVIN-VARLEY OUTPUT

15. The second set of terminals provide an output from the Kelvin-Varley Divider. The maximum output is 10 vdc when the instrument range selector is in the 10-volt position. A chart showing the output impedance of the KVD is located in the back of this manual.

OPERATING INSTRUCTIONS (Continued)

AC MODE

16. Follow instructions under DC MODE, paragraphs 1, 2, and 3.

17. For best results, connect the ground terminal to the negative terminal. However, in most applications the input may be left floating.

18. Polarity switch must be set to AC.

19. Turn the range selector knob to the desired range. Connect the voltage to be measured to the input terminal posts. The voltage now indicated on the meter is accurate within 4%.

20. Position the first two readout dials to the approximate TVM voltage reading. Advance the null selector knob to the 1-volt position. Continue to adjust the readout while increasing the null sensitivity. You are now zeroing in on the null.

21. When, by the procedure above, the null selector is at full sensitivity and the meter reading zero, the voltage read from the dials is accurate to better than the rated accuracy of the instrument. Because the sensitivity of your instrument in its most sensitive position is higher than the stability of many sources, you may not get a reading of zero if the voltage you are measuring is not constant and is fluctuating.

OPERATING INSTRUCTIONS (Continued)

READING EXCURSIONS ABOUT A NOMINAL VOLTAGE

22. To read excursions of voltage about a nominal value, set the readout dials to the nominal value. Excursions may be observed directly on the meter on any of the four null ranges. A right hand deflection of the meter indicates the voltage has increased above the nominal value by the amount indicated on the meter. For voltages read on the 10-volt range, use null sensitivity selector as marked. On the 100-volt ranges, the null sensitivity selector value must be multiplied by a factor of 10. On the 1000-volt range the null sensitivity selector value must be multiplied by a factor of 100.

DIRECT MEASUREMENTS OF 10 VOLTS AND ABOVE

23. With the range selector in the 10-volt position, use full scale values as marked on the meter. When range selector is in the 100-volt position, multiply the meter reading by 10. On the 1000-volt range, multiply the reading by 100.

VARIATIONS IN NULL DETECTOR SENSITIVITY

24. Due to the circuit design on the 100-volt range, the null detector will have reduced sensitivity on the 1 mv and 10 mv positions. This is due to a high internal source impedance of the high voltage input divider. The sensitivity is about 50% less in the 1 mv null position and about 15% less on the 10 mv position. Only a very slight loss of sensitivity is noticed on the other null ranges. When the range selector is in the 1000-volt position, a 10% loss of sensitivity will be noticed in the 1 mv position.

CIRCUIT DESCRIPTION

DC SECTION

This Calibration Standards Corporation Voltmeter is designed for long, trouble-free life. There are no batteries or components that would normally need replacing.

This dependable voltmeter operates on the principle of comparing an unknown voltage with an adjustable known voltage. A sensitive null detector is used to provide a means of sensing when the known and unknown voltages are equal.

The DC section of the voltmeter is composed of three basic elements:

(1) An ultra stable reference supply.

(2) An accurate Kelvin-Varley divider.

(3) A sensitive null detector.

CIRCUIT DESCRIPTION (Continued)

1. The heart of the voltmeter is the ultra stable reference voltage supply. This supply is a dual regulated transistor supply powering a compensated Zener reference string. The transistors and Zener diodes are silicon, and therefore will withstand high temperatures without impairing the life of the assembly. Following is a performance chart of the references.

Model	Regulation for 10% line change 15°C to 41°C	Temperature Coefficient	Long-term stability of Zener Element Typical	Maximum
AC-210B-1/BR-1	±0.001%	*	±10 ppm	±20 ppm
AC-200B-1/BR-1	±0.001%	±3 ppm/°C	±10 ppm	±20 ppm
AC-150B-1/BR-1	±0.001%	±3 ppm/°C	±10 ppm	±20 ppm
AC-110B-1/BR-1	±0.002%	±5 ppm/°C	±20 ppm	±40 ppm
AC-100B-1/BR-1	±0.005%	±5 ppm/°C	±20 ppm	±50 ppm

This reference voltage supply is constructed as a printed circuit assembly. Spares and replacements are available from the factory. When ordering, be sure to indicate the serial number of the instrument.

*The Zener reference is enclosed in a proportional control oven holding the temperature to better than ±0.1°C.

CIRCUIT DESCRIPTION. (Continued)

2. The second basic element is the very accurate Kelvin-Varley Divider. All readout decks except the last have 11 carefully matched precision wire-wound resistors. The chart below shows the maximum Kelvin-Varley divider linearity and yearly stability.

Model	Linearity	Maximum Stability	Typical Stability
AC-210B-1/BR-1	±20 ppm	±5 ppm	±1-2 ppm
AC-200B-1/BR-1	±20 ppm	±5 ppm	±1-2 ppm
AC-150B-1/BR-1	±25 ppm	±5 ppm	±1-2 ppm
AC-110B-1/BR-1	±75 ppm	±20 ppm	±3-5 ppm
AC-100B-1/BR-1	±100 ppm	±20 ppm	±3-5 ppm

Since the divider resistors operate at very low power ratings, the long-term stability of the divider is that of the long-term ratio stability at shelf-life. The resistors are preaged and tested for best stability before installation in the instrument.

The resistors used in the first deck of the AC-210B-1/BR-1, AC-200B-1/BR-1, and AC-150B-1/BR-1 Kelvin-Varley Divider are the most stable type of resistor possible to manufacture. They are wound with very little strain and are sealed in silicon oil. Resistors of this type are also utilized in the range divider network.

The range selector precedes the Kelvin-Varley Divider. Each range has a fine adjustment potentiometer for calibration. Each is calibrated seperately.

CIRCUIT DESCRIPTION (Continued)

3. The third element is a very sensitive and stable calibrated null detector. This null detector is used to indicate the difference between an unknown external voltage and a known internal voltage. At maximum sensitivity the null detector has a full-scale deflection of 1 mv. This provides ample sensitivity for accurate low-level voltage measurements. The TVM accuracy is ±4% of full scale over a temperature range of 10°C to 40°C. The instrument is usable to 50°C but some derating should be considered.

The null detector is capable of a long, trouble-free life except for the occasional replacement of the chopper. These are highly reliable, however, do occasionally need replacement. Choppers are available from stock at the factory. The occasional calibration of the null detector may be made by adjusting the gain-adjustment potentiometer, R32, located in the amplifier printed circuit board. An electrical zero control, R31, is also located on this board.

The null detector is capable of large overloads without damage. On the 1 mv range a safe overload would be 50 volts short-term and 10 volts long-term. On the 10 mv, 100 mv, and 1V positions, a safe overload of 500 volts is possible.

CIRCUIT DESCRIPTION (Continued)

In the VTVM position ranges, safe overloads are as follows.

1-volt range:	70 volts
10-volt range:	250 volts
100-volt range:	700 volts
1000-volt range:	1500 volts

CIRCUIT DESCRIPTION

The AC to DC converter in the AC voltmeter develops a DC output proportional to the AC input voltage being measured. The instrument responds to the average value of one half cycle of the input voltage. The output is calibrated in RMS. Since the majority of measurements involve true sine waves or those of relatively small distortion, the average and RMS values have a linear relationship.

The input impedance of the AC voltmeter is 1 megohm shunted with 25 picofarads on the 1, 10, 100 volt AC ranges, and 2 megohms shunted with 25 picofarads on the 1000 volt AC range.

A precision input attenuator is used on the 100 and 1000 VAC ranges to reduce the input to 0-10 volts for the AC to DC converter. On the 1 VAC range the gain is increased by a factor of 10. The output of the converter is always 0-10V on any range and is compared against the 10V decade on the DC side of the voltmeter.

The converter amplifier power is furnished by an extremely well regulated and filtered supply. The heater of the 6CW4 nuvistor (low noise first stage) is supplied from a similar source. The amplifier has an open loop gain of greater than 50,000 and a closed loop gain of approximately 2 (20 on the 1 VAC range). The use of a high degree of negative feedback stabilizes the amplifier gain, reduces the variations caused by changes in the active components, broadens the frequency response, and minimizes the inherent non-linearity of the silicon rectifier diodes located in the feedback loop.

CALIBRATION

DC

A suggested setup for calibrating the instrument is included in this manual.

A. CALIBRATION OF THE DIFFERENTIAL SECTION

The "RANGE SELECTOR" - "10V" range is calibrated first. On this range the instrument has an infinite input resistance at null.

1. Check mechanical zero of meter. If necessary, adjust to zero by means of the screw in the center of the meter case.
2. Next, turn "NULL SELECTOR" to the TVM position and power switch on. Check electrical zero of meter. If necessary, adjust to zero by means of R31.
3. Apply a known 10-volt calibration voltage across the "POS" and "NEG" input terminals. The instrument meter should read full scale. Turn "READOUT" dials to read (9). (9) (9) (9) (10) and turn "NULL SELECTOR" switch to the "1 MV" position. Bring meter to zero by adjusting the appropriate calibration trim potentiometer. (See calibration board component layout.)
4. Repeat the basic procedure for calibration of the "1V" range using a known 1 volt. Repeat the basic procedure for calibration of the "00 mv" range using a known 100 mv source. (Omit where not applicable.)
5. The "RANGE SELECTOR" - "100V" and "1000V" ranges are calibrated next. On these ranges the instrument has a 2 megohm input resistance.
6. Turn the "RANGE SELECTOR" switch to the "100V" position and apply a known 100-volt calibration voltage at meter input. Continue basic calibration procedure outlined in paragraph 3.

NOTE: Multiply "NULL SELECTOR" ranges by 10.

CALIBRATION (Continued)

7. Turn the "RANGE SELECTOR" switch to the "1000V" position. Apply a known 500 volts with the "READOUT" dials turned to (5) (0) (0) (0) (0) (0). Bring meter to zero by adjusting the appropriate trim potentiometer.

B. CALIBRATION OF THE TVM RANGES

Calibrate the TVM Ranges by setting the "RANGE SELECTOR" switch to the "10V" position and apply a known 10-volt calibration voltage. Adjust potentiometer R32 for full-scale deflection. It is not necessary to calibrate the remaining TVM ranges.

3. CALIBRATION, AC

3.1 Equipment Required:

3.1.1 Stable, low distortion AC source. Capable of providing 500, 50, 5, and 1.0 VAC at 400 cycles, 5 kilocycles, and 10 kilocycles. Voltage stability and accuracy better than .03%. Hold Model 323A or equivalent.

3.1.2 Transfer Standard. Sensitive Research Model FLH with Galvanometer, or equivalent.

3.1.3 DC Power Source. 0-500 vdc short-term stability, better than .005%. CSC Model VS-100BR or equivalent.

3.1.4 DC Differential Voltmeter. Accuracy better than .02% from 0 to 500 volts. CSC Model DC-110B, or equivalent.

3.2 Equipment Set-Up:

3.2.1 Connect equipment as shown in diagram.

3.2.2 The Transfer Standard and DC Power Source may be omitted providing AC source is within the specifications of 3.1.1.

3.3 Procedure:

3.3.1 Refer to manual page showing component and adjustment locations.

3.3.2 Perform DC calibration before proceding with AC.

3.3.3 Set range switch to 10 volt position.

3.3.4 Set AC source to 5 volts 400 cycles.

3.3.5 Set R113 to approximately mid range.

3.3.6 Adjust R99, advancing null sensitivity, until meter is at null.

3.3.7 If null cannot be obtained within range of R99, reset R113 and repeat 3.3.6.

3.3.8 Set AC source to 5 volts 10 kc.

3.3.9 Adjust C26, advancing null sensitivity, until meter is at null.

CALIBRATION (continued)

3. CALIBRATION, AC (continued)

3.3.10 Set range switch to 1 volt position.

3.3.11 Set AC source to 1.0 volts 400 cycles.

3.3.12 Adjust R95 until meter is at null. (Note that null sensitivity increases by a factor of 10X, 10 mv null range should be used).

3.3.13 Set AC source to 1.0 volts 10 kc.

3.3.14 Adjust C43 until meter is at null.

3.3.15 Set range switch to 100 volt position.

3.3.16 Set AC source to 50 volts 400 cycles.

3.3.17 Adjust R77 until meter is at null.

3.3.18 Set AC source to 50 volts 10 kc.

3.3.19 Adjust C35 until meter is at null.

3.3.20 Set range switch to 1000 volt position.

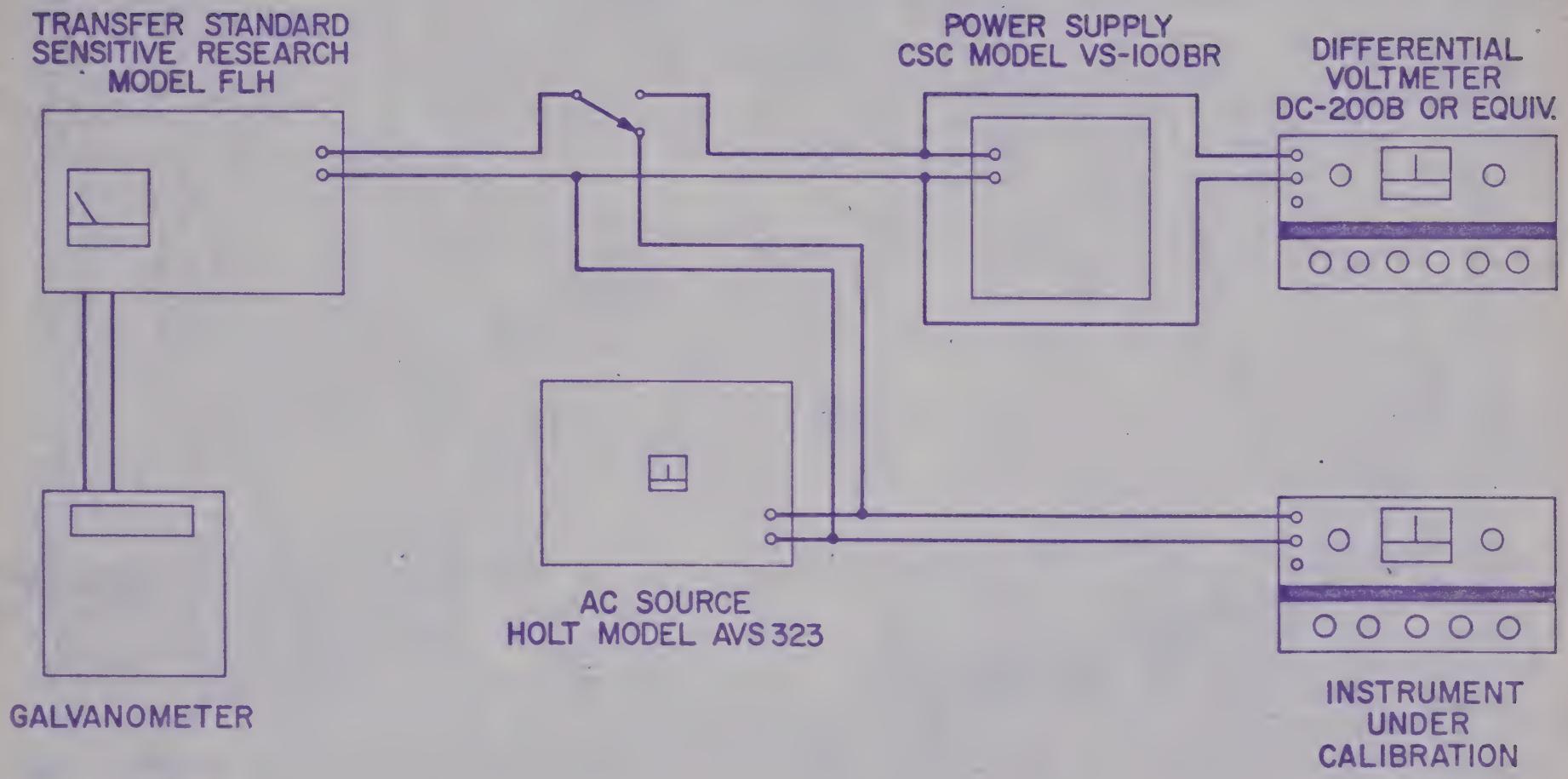
3.3.21 Set AC source to 500 volts 400 cycles.

3.3.22 Adjust R78 until meter is at null.

3.3.23 Set AC source to 500 volts 10 kc.

3.3.24 Adjust C36 until meter is at null.

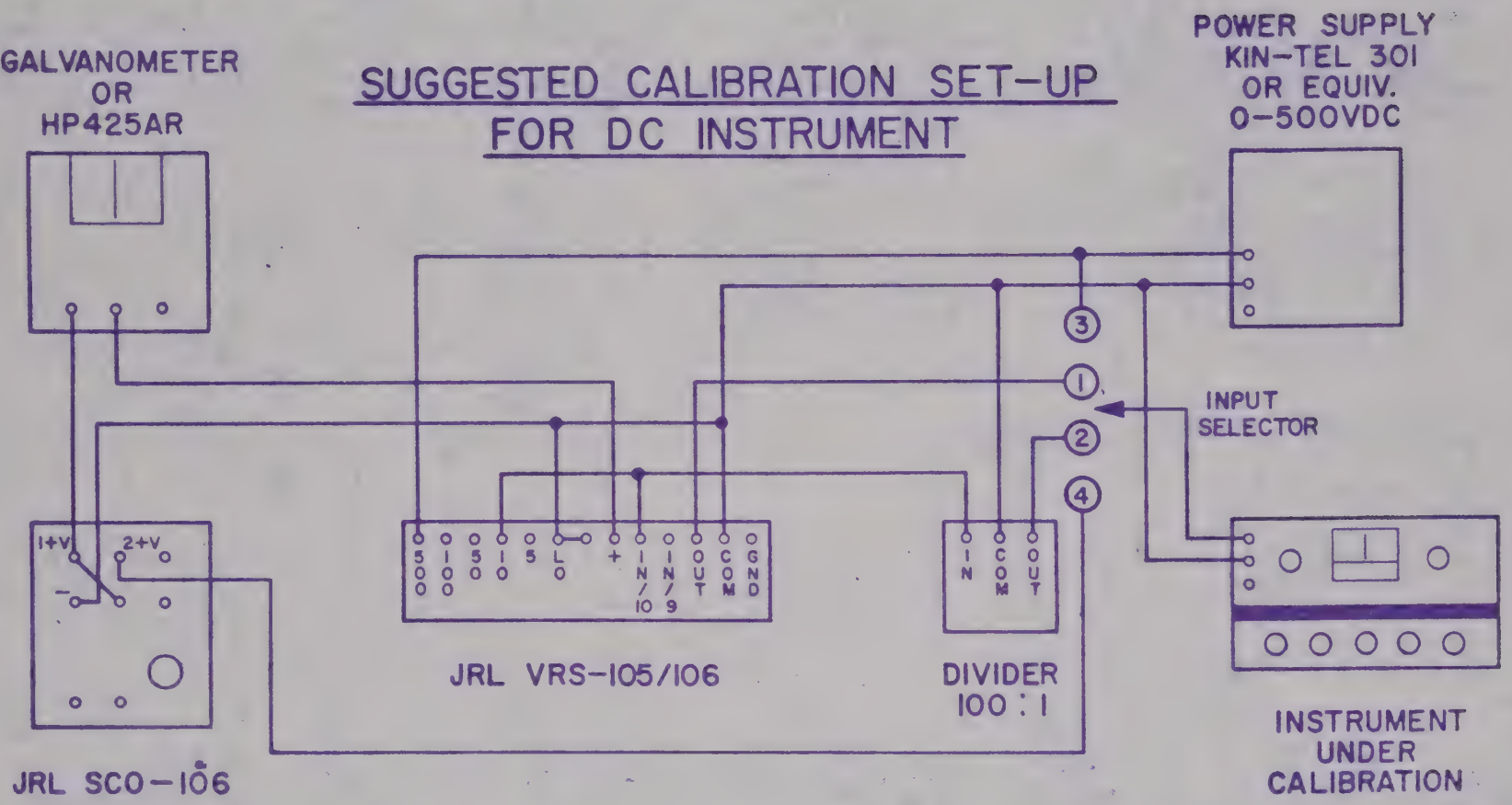
SUGGESTED CALIBRATION SET-UP FOR AC INSTRUMENT



JULIE RESEARCH LABS MODEL SCO-106 CELL ACCURACY 1-2PPM.

JULIE RESEARCH LABS MODEL VRS-105/106 ACCURACY 10PPM CALIBRATOR-10PPM RATIO.

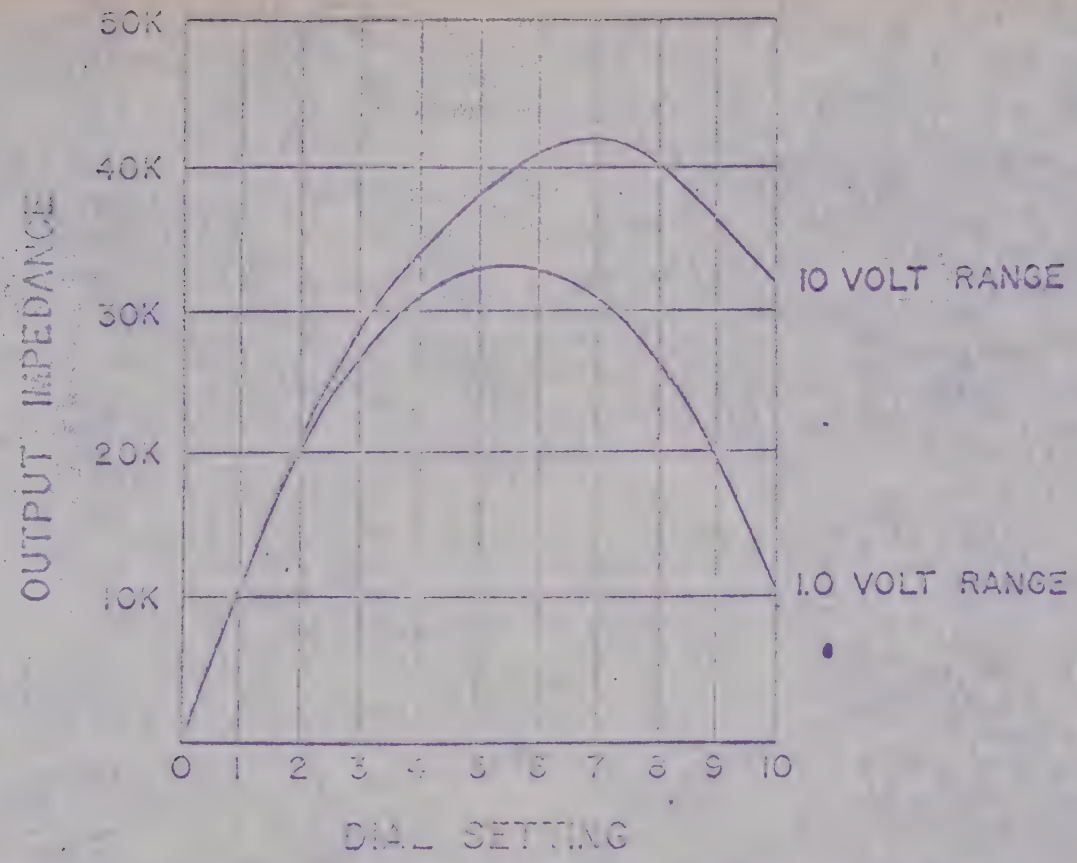
SUGGESTED CALIBRATION SET-UP FOR DC INSTRUMENT



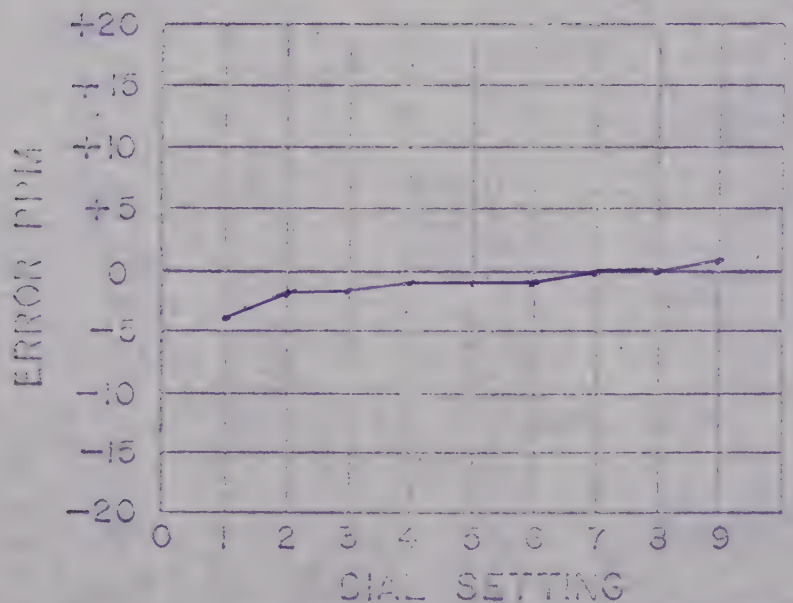
3. CARE SHOULD BE TAKEN WHEN OPERATING INSTRUMENT IN NEGATIVE MODE AS SHORTS MAY DAMAGE OR SHORTEN LIFE OF TEST EQUIPMENT.
2. FOR CALIBRATION OF 100MV RANGE DIVIDER SHOULD BE OF AT LEAST 20PPM ACCURACY.
1. FOR CALIBRATION OF 1.0V RANGE SET RATIO ON DIVIDER (JRL) TO 1.

NOTES:

RANGE	INPUT SELECT.	POWER SUPPLY	VRS RATIO	VRS 105
1000V	3	500V	N. U.	500V
100V	3	100V	N. U.	100V
10V	4	10V	N. U.	10V
1.0V	1	10V	10 : 1	10V
100MV	2	10V	N. U.	10V



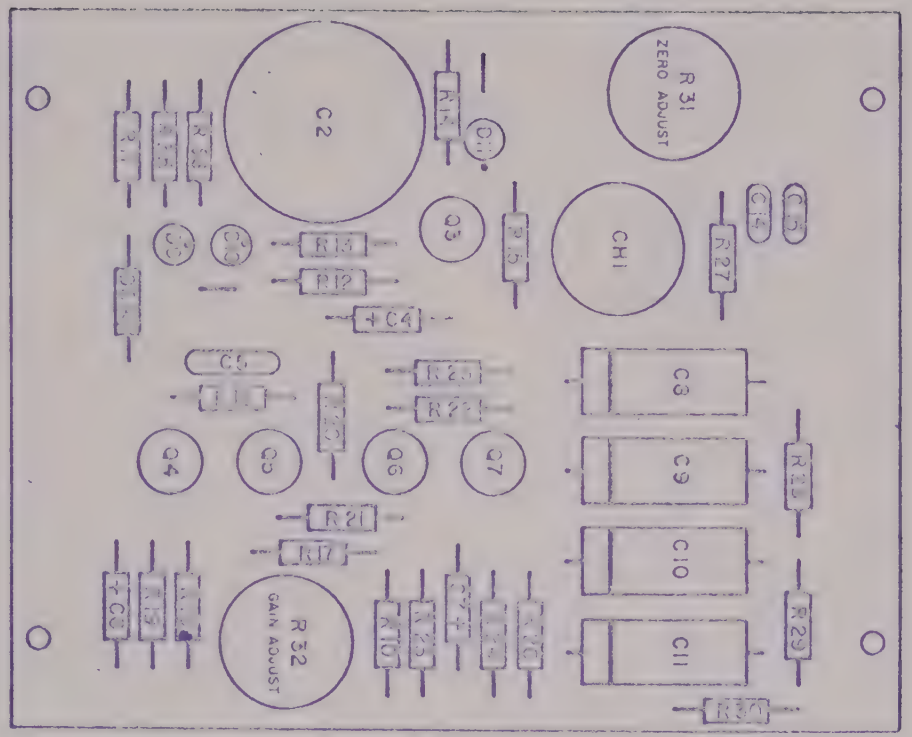
OUTPUT IMPEDANCE OF REFERENCE / KVD



KELVIN VARLEY DIVIDER CALIBRATION CHECKED AGAINST CSC 1PPM MASTER DIVIDER.

KVD CALIBRATION CHART

INSTRUMENT MODEL AC-210B-1 INSTRUMENT SERIAL NO. 9270018

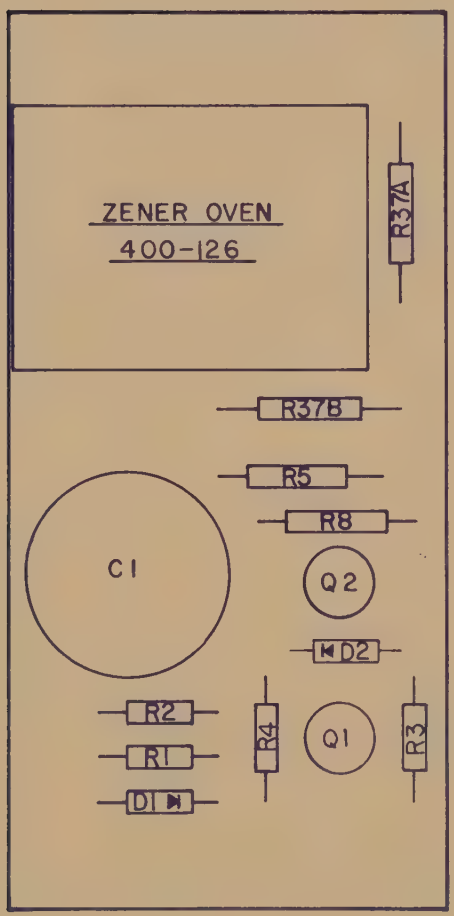


COMPONENT LOCATION AMPLIFIER

400-106

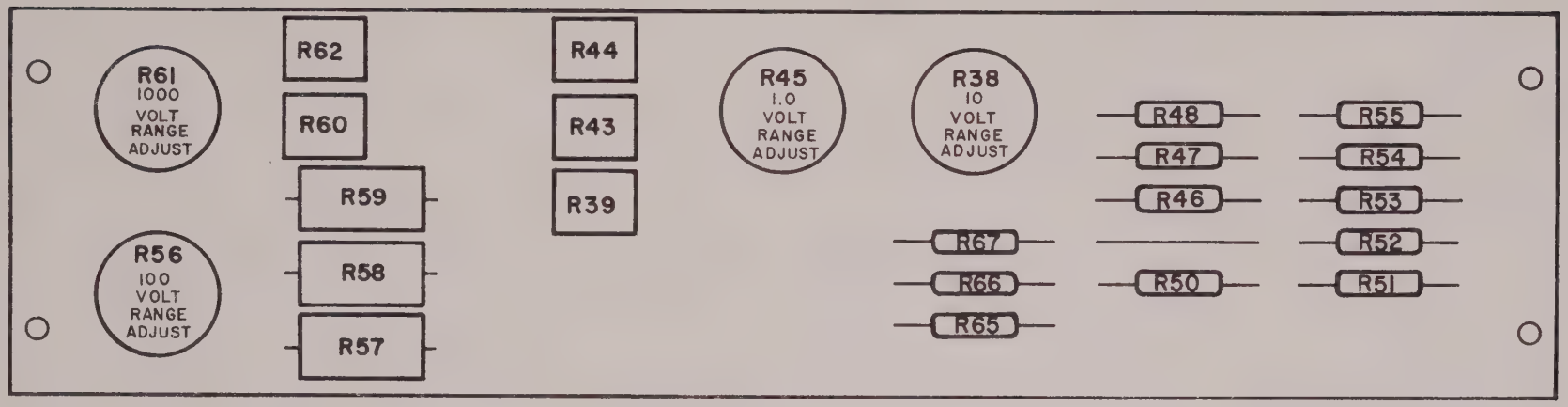
(REVISION A)

R37 MAY BE COMPOSED OF
ONE OR TWO RESISTORS



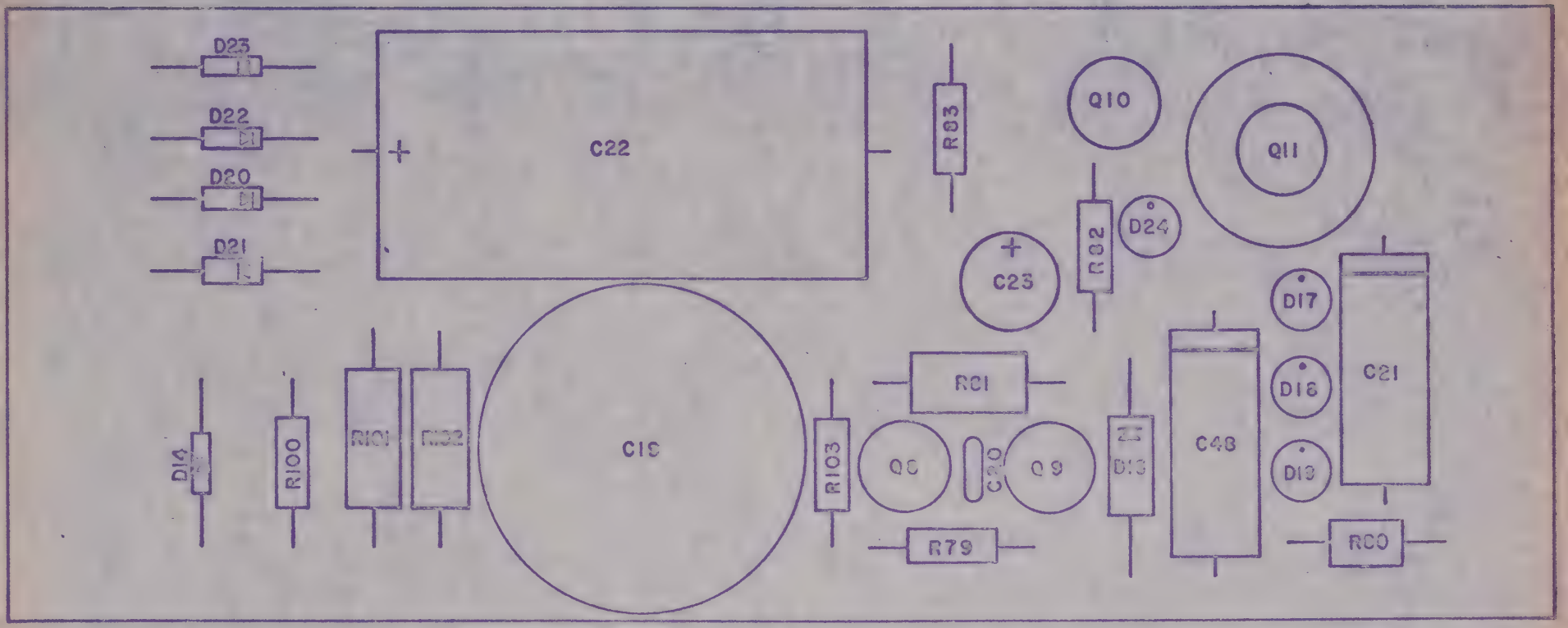
COMPONENT LOCATION OVEN REFERENCE

400-125



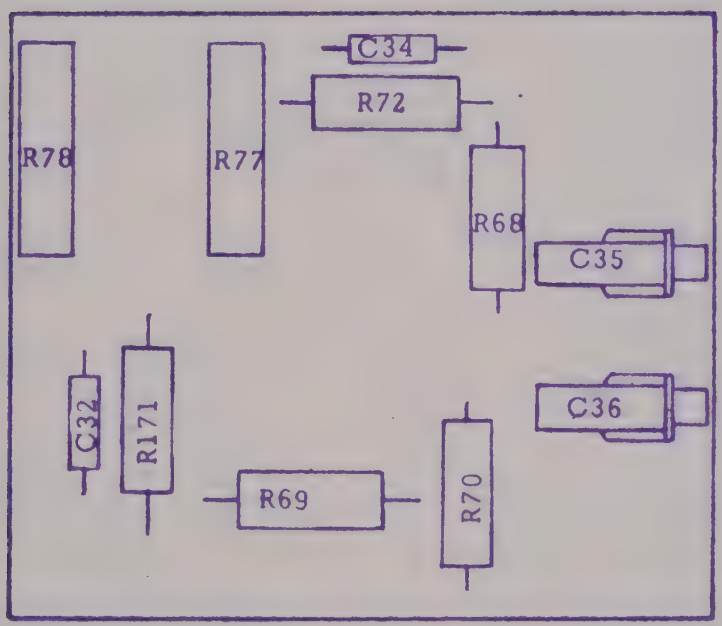
COMPONENT LOCATION CALIBRATION

400—145



COMPONENT LOCATION POWER SUPPLY

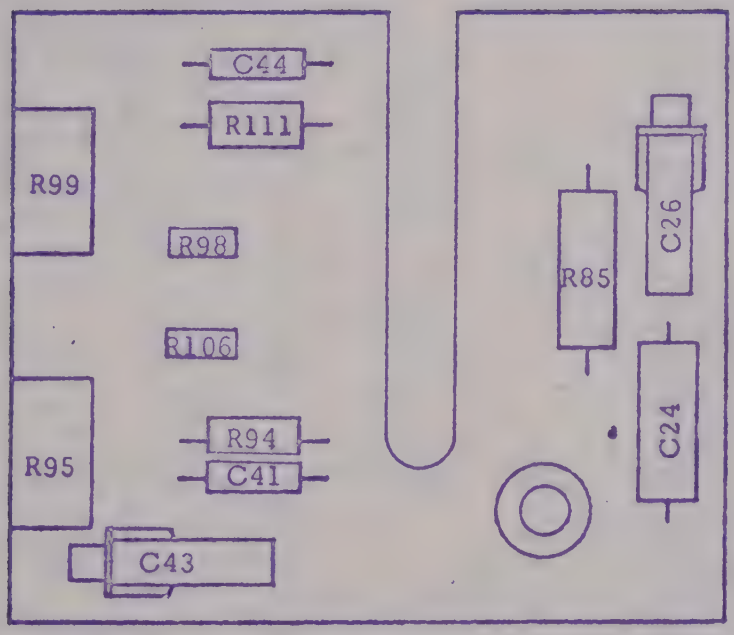
400-175



COMPONENT LOCATION

AC HIGH VOLTAGE DIVIDER

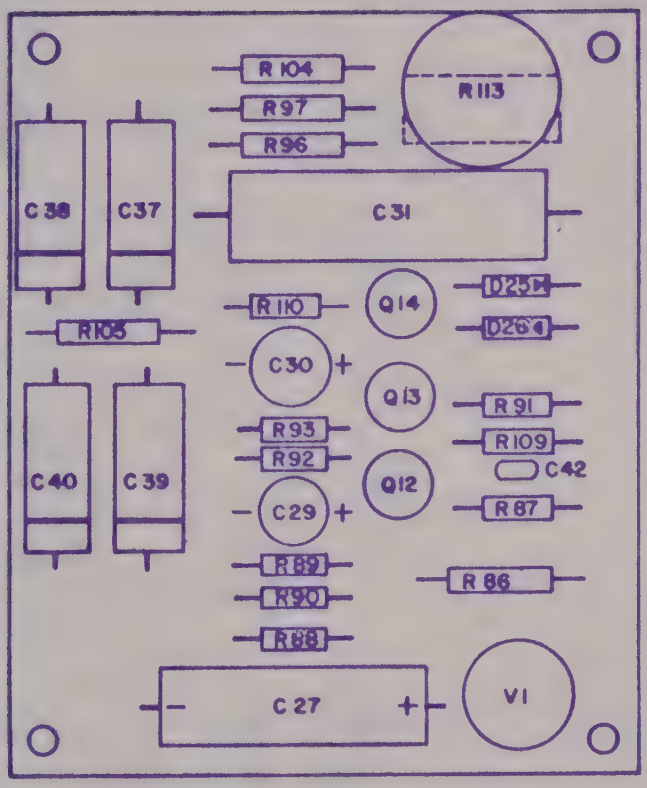
400-208



COMPONENT LOCATION

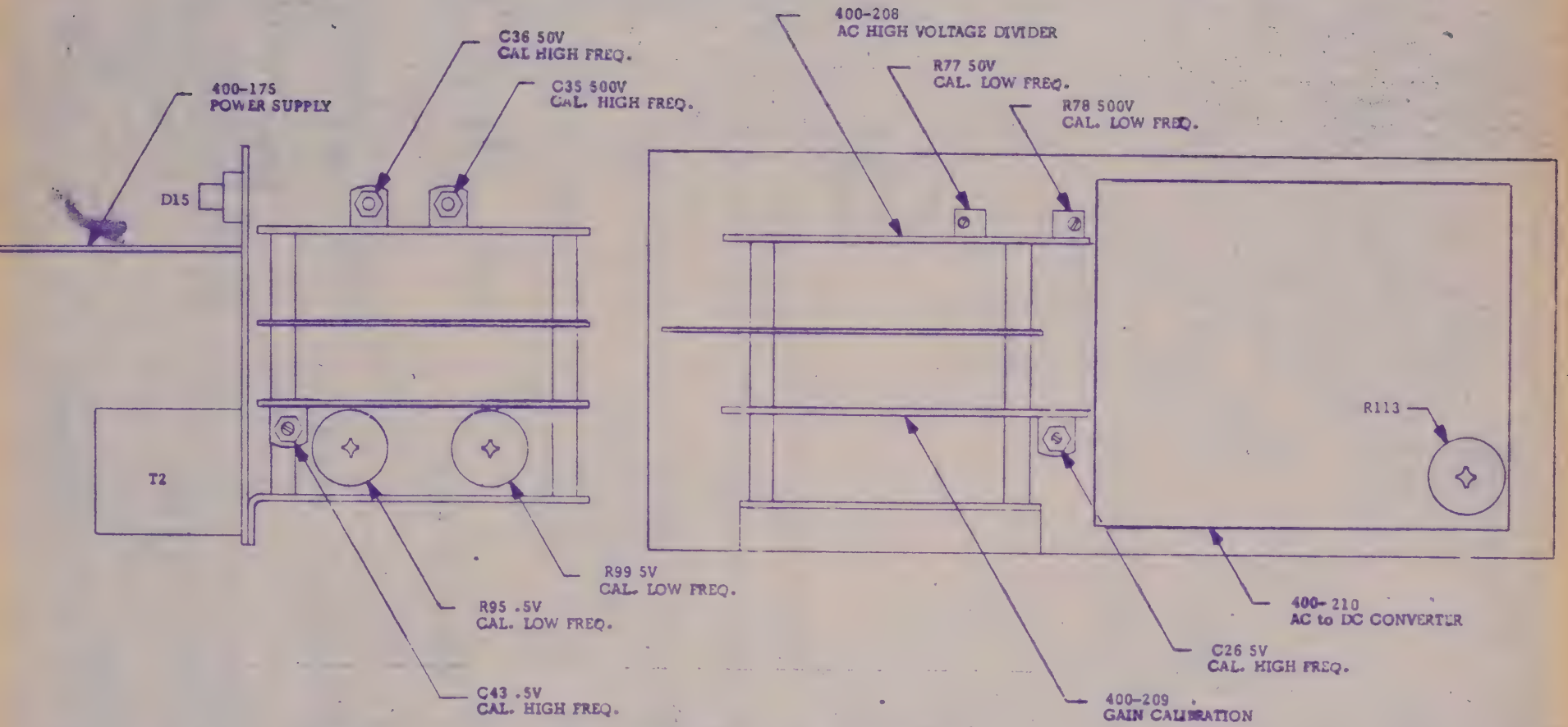
GAIN CALIBRATION

400-209

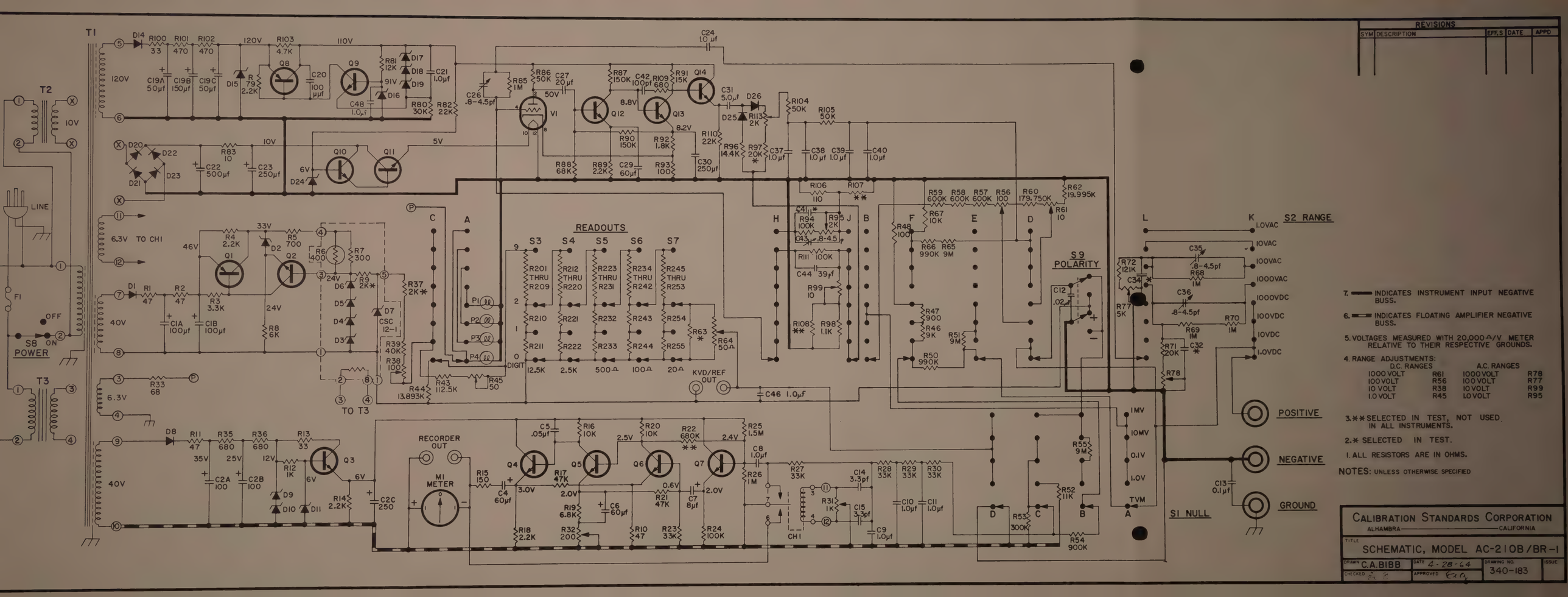


COMPONENT LOCATION AC TO DC CONVERTER

400-210



COMPONENT AND ADJUSTMENT LOCATION



REVISIONS				
SYM	DESCRIPTION	EFF. S	DATE	APPD

7. ▬ INDICATES INSTRUMENT INPUT NEGATIVE BUSS.

6. ▬ INDICATES FLOATING AMPLIFIER NEGATIVE BUSS.

5. VOLTAGES MEASURED WITH 20,000Ω/V METER RELATIVE TO THEIR RESPECTIVE GROUNDS.

4. RANGE ADJUSTMENTS:

D.C. RANGES		A.C. RANGES	
1000 VOLT	R61	1000 VOLT	R78
100 VOLT	R56	100 VOLT	R77
10 VOLT	R38	10 VOLT	R99
1.0 VOLT	R45	1.0 VOLT	R95

3. ** SELECTED IN TEST, NOT USED IN ALL INSTRUMENTS.

2. * SELECTED IN TEST.

1. ALL RESISTORS ARE IN OHMS.

NOTES: UNLESS OTHERWISE SPECIFIED

CALIBRATION STANDARDS CORPORATION
ALHAMBRA — CALIFORNIA

TITLE: SCHEMATIC, MODEL AC-210B/BR-1

DRAWN	DATE	DRAWING NO.	ISSUE
C.A.BIBB	4-28-64	340-183	
CHECKED	APPROVED		

REPLACEMENT PARTS LIST (Continued)

Reference or Quantity	Description	Stock Number
Calibration Board Sub-Assembly, 400-108		
R39	Resistor, WW, 40KΩ, .05%, 1/3W	203-503
R43	Resistor, WW, 112.5KΩ, .02%, 1/3W	203-504
R44	Resistor, WW, 13.893KΩ, .02%, 1/3W	203-501
R46	Resistor, DC, 9KΩ, 1%, 1/2W	205-001
R47	Resistor, DC, 900Ω, 1%, 1/2W	205-039
R48	Resistor, DC, 100Ω, 1%, 1/2W	205-036
R49	Resistor, DC, 90KΩ, 1%, 1/2W	205-004
R50, R54	Resistor, DC, 900KΩ, 1%, 1/2W	205-002
R51, R55	Resistor, DC, 9MΩ, 1%, 1/2W	205-005
R52	Resistor, DC, 11KΩ, 1%, 1/2W	205-008
R53	Resistor, DC, 300KΩ, 1%, 1/2W	205-009
R57, R58, R59	Resistor, WW, 600KΩ, .02%, 1/3W	203-551
R60	Resistor, WW, 179.975KΩ, .02%, 1/3W	203-521
R61	Resistor, Variable, 10Ω	210-015
R62	Resistor, WW, 19.995KΩ, .02%, 1/3W	203-502
R45	Resistor, Variable, 50Ω	210-014
R38	Resistor, Variable, 200Ω	210-009
R56	Resistor, Variable, 100Ω	210-011

REPLACEMENT PARTS LIST (Continued)

Reference or Quantity	Description	Stock Number
Amplifier Sub-Assembly, 400-106		
R10, R11	Resistor, FC, 47Ω, 10%, 1/2W	201-470
R12	Resistor, FC, 1KΩ, 10%, 1/2W	201-102
R13	Resistor, FC, 33Ω, 10%, 1/2W	201-330
R14, R18	Resistor, FC, 2.2KΩ, 10%, 1/2W	201-222
R15	Resistor, FC, 150Ω, 10%, 1/2W	201-151
R16, R20,	Resistor, FC, 10KΩ, 10%, 1/2W	201-103
R17, R21	Resistor, FC, 47KΩ, 10%, 1/2W	201-473
R19	Resistor, FC, 6.8KΩ, 10%, 1/2W	201-682
R22	Resistor, FC, 680KΩ, 10%, 1/2W	201-684
R23, R27, R28, R29, R30	Resistor, FC, 33KΩ, 10%, 1/2W	201-333
R24	Resistor, FC, 100KΩ, 10%, 1/2W	201-104
R25	Resistor, FC, 1.5MΩ, 10%, 1/2W	201-155
R26	Resistor, FC, 1.0MΩ, 10%, 1/2W	201-105
R35, R36	Resistor, FC, 680Ω, 10%, 1/2W,	201-681
R31	Resistor, Variable, 1KΩ	210-010
R32	Resistor, Variable, 200Ω	210-009
C2A, C2B, C2C	Capacitor, Triple Electrolytic, 100-100-250 mfd, 50-50 vdc	222-014
C4, C6	Capacitor, Tantalum, 60 mfd, 6 vdc	223-008
C5	Capacitor, Disc, .05 mfd, 75 vdc	220-002
C7	Capacitor, Tantalum, 8.2 mfd, 20 vdc	223-009

REPLACEMENT PARTS LIST (Continued)

Reference or Quantity	Description	Stock Number
Amplifier Sub-Assembly, 400-106 (continued)		
C8, C9, C10, C11	Capacitor, Mylar, 1 mfd, 100 vdc	220-033
D8	Diode	216-025
D9, D10	Zener Diode	216-004C
D11	Zener Diode	216-004A
Q3, Q4, Q5, Q6, Q7	Transistor, NPN Silicon	215-015A
CH1	Chopper	230-004
5	Pad, Transistor	218-004
1	Socket, 7-pin	260-011
C14, C15	Capacitor, 3.3 mmf	220-007

REPLACEMENT PARTS LIST

Reference or Quantity	Description	Stock Number
Calibration Board Sub-Assembly, 400-145		
R39	Resistor, WW, 40KΩ, .05%, 1/3W	203-503
R43	Resistor, WW, 112.5KΩ, .02%, 1/3W	203-504
R44	Resistor, WW, 13.893KΩ, .02%, 1/3W	203-501
R46	Resistor, DC, 9KΩ, 1%, 1/2W	205-001
R47	Resistor, DC, 900Ω, 1%, 1/2W	205-039
R48	Resistor, DC, 100Ω, 1%, 1/2W	205-036
R50, R66	Resistor, DC, 990KΩ, 1%, 1/2W	205-028
R51, R55, R65	Resistor, DC, 9MΩ, 1%, 1/2W	205-005
R52	Resistor, DC, 11KΩ, 1%, 1/2W	205-008
R53	Resistor, DC, 300KΩ, 1%, 1/2W	205-009
R54	Resistor, DC, 900KΩ, 1%, 1/2W	205-002
R56	Resistor, Variable, 100Ω	210-011
R57, R58, R59	Resistor, WW, 600KΩ, .02%, 1/3W	203-551
R60	Resistor, WW, 179.975KΩ, .02%, 1/3W	203-521
R61	Resistor, Variable, 10Ω	210-015
R62	Resistor, WW, 19.995KΩ, .02%, 1/3W	203-502
R45	Resistor, Variable, 50Ω	210-014
R38	Resistor, Variable, 200Ω	210-009
R67	Resistor, DC, 10KΩ, 1%, 1/2W	205-007

[illegible] (Continued)

Reference Designation	Description	Part Number
[illegible]-Varley Divider [illegible] mbly, 400-115**		
S3	Switch, Rotary	240-046
R201-R211	Resistor, WW, 12.5KΩ, .01%, 1/3W	203-303
Kelvin-Varley Divider, 2,500Ω, Sub-Assembly, 400-116**		
S4	Switch, Rotary	240-046
R212-R222	Resistor, WW, 2.5KΩ, .05%, 1/3W	203-132
Kelvin-Varley Divider, 500Ω, Sub-Assembly, 400-117**		
S5	Switch, Rotary	240-046
R223-R233	Resistor, WW, 500Ω, .05%, 1/3W	203-102
[illegible]		
S6	Switch, Rotary	240-046
R234-R244	Resistor, WW, 100Ω, .1%	203-106
Kelvin-Varley Divider, 20Ω, Sub-Assembly [illegible]		
S7	Switch, Rotary	240-046
R245-R255	Resistor, WW, 20Ω, .5%	203-107
R256	Resistor, Variable, WW, 50Ω	210-010
R03	Resistor, FC, 10%, 1/2W	**

REPLACEMENT PARTS LIST

Reference or Quantity	Description	Stock Number
Converter Power Supply, 400-175		
R83	Resistor, FC, 10Ω, 10%, 1/2W	201-100
R103	Resistor, FC, 4.7KΩ, 10%, 1/2W	201-472
R79	Resistor, FC, 2.2KΩ, 10%, 1/2W	201-222
R82	Resistor, FC, 22KΩ, 10%, 1/2W	201-223
R100	Resistor, FC, 33Ω, 10%, 1/2W	201-330
R101, R102	Resistor, FC, 470Ω, 10%, 1W	2011471
R81	Resistor, WW, 12K	203-203
R80	Resistor, WW, 30K	203-204
Q9, Q10, Q11	Transistor	215-015D
Q8	Transistor	215-036
D24	Diode	216-004D
D17, D18, D19	Diode	216-004A
D15	Diode	216-014
D14,D20,D21,D22,D23	Diode	216-025
D16	Diode	216-106
C20	Capacitor, 100pf @ 1KV	220-009
C21, C48	Capacitor, 1.0uf @ 200V	220-033
C19	Capacitor, 150-50-50uf @ 150V	222-018
C23	Capacitor, 250uf @ 10V	222-019
C22	Capacitor, 500uf @ 50V	222-022
T2	Transformer	235-043

REPLACEMENT PARTS LIST

Reference or Quantity	Description	Stock Number
Converter Sub-Assembly, 400-210		
R93	Resistor, FC, 100Ω, 10%, 1/2W	201-101
R91	Resistor, FC, 15KΩ, 10%, 1/2W	201-153
R87, R90	Resistor, FC, 150KΩ, 10%, 1/2W	201-154
R92	Resistor, FC, 1.8KΩ, 10%, 1/2W	201-182
R89	Resistor, FC, 2.2KΩ, 10%, 1/2W	201-222
R110	Resistor, FC, 22KΩ, 10%, 1/2W	201-223
R109	Resistor, FC, 680Ω, 10%, 1/2W	201-681
R88	Resistor, FC, 68KΩ, 10%, 1/2W	201-683
R86, R104, R105	Resistor, DC, 50KΩ, 1%, 1/2W	205-011
R96	Resistor, DC, 14.4K, 1%, 1/2W	205-049
R97	Resistor, WW, 19.4K, 1%, 1/2W	205-050
R113	Resistor, Variable, 2K	210-029
Q13, Q14	Transistor	215-015C
Q12	Transistor	215-015F
D25, D26	Diode	216-010
V1	Nuvistor	217-015
C42	Capacitor, 100pf @ 1KV	220-009
C37,C38,C39,C40	Capacitor, 1.0uf @ 200V	220-033
C31	Capacitor, 5.0uf @ 200V	220-035
C30	Capacitor, 250uf @ 10V	222-019
C27	Capacitor, 20uf @ 100V	222-021
C29	Capacitor, 60uf @ 25V	223-008

REPLACEMENT PARTS LIST

Reference or Quantity	Description	Stock Number
AC Divider, Gain Calibration and Switching, Sub-Assembly, 410-004		
R106	Resistor, WW, 110Ω, 1/4%, 1/8W	203-150
R98	Resistor, WW, 1.1KΩ, 1/4%, 1/8W	203-151
R94, R111	Resistor, WW, 100KΩ	203-623
R68, R69, R70, R85	Resistor, MF, 1MΩ, 1%, 1/2W	206-002
R72	Resistor, MF, 121KΩ, 1%, 1/2W	206-003
R71	Resistor, MF, 20KΩ, 1%, 1/2W	206-005
R78	Resistor, Variable, 1KΩ	210-006
R77	Resistor, Variable, 5K	210-007
R99	Resistor, Variable, 10Ω	210-015
R95	Resistor, Variable, 2K	210-029
R107, R108	Resistor, DC	****
C41, C44	Capacitor, Disc	****
C34	Capacitor, Disc	****
C32	Capacitor, Disc	****
C24	Capacitor, 1.0 uf @ 200V	220-033
C26,C35,C36,C43	Capacitor, Variable, .8-4.5pf	224-001
S1A,B,C,D,E,F,G	Switch, Range	240-078
S1H,J,K,L	Switch, Range	240-087

**** Approx value selected in test

REPLACEMENT PARTS LIST (Continued)

Reference or Quantity	Description	Stock Number
T1	Power Transformer, 115 vac, 50-60 cps Power Transformer, 230 vac, 50-60 cps	235-015 235-017
C12	Capacitor, Disc, .02 mfd, 1K vdc	220-001
F1	Fuse, 3 AG, 1/4 amp	261-005
1	Fuse Holder	261-002
1	Line Cord	264-001
1	Strain Relief	283-001
5	KVD Switch Readout Dial	400-112
1	KVD Pot Readout Dial	400-113
S1	Switch, Rotary, Null	240-044
S8	Switch, Toggle, SPST	240-047
S9	Switch, Toggle, DPDT	240-026
M1	Meter, 100-0-100 micro-amp-TB (Model 100 only) - P&J	250-008 250-001
1	Bezel, meter	250-009
1	Terminal Post, Red	263-105
2	Terminal Post, Black	263-106
R33	Resistor, FC, 68Ω, 10%, 1/2W	201-680
4	Lamp, Decimal	400-114
2	Knob, Range & Null	214-010
6	Knob, KVD	214-011
1	Cover, Instrument (B only)	310-080
1	Handle, Instrument (B only)	285-004

REPLACEMENT PARTS LIST (Continued)

Reference or Quantity	Description	Stock Number
4	Feet, Rubber	283-003
1	Test Lead, Red	264-003
1	Test Lead, Black	264-002
C13	Capacitor, 0.1 mfd, 1000 vdc	220-040

NOTES

* (A) D7, the reference Zener diode, is carefully selected and stabilized by Calibration Standards Corporation. R9 is a precision wire wound resistor carefully selected to control the current through the reference diode, D7. R37 is a precision wire wound resistor, factory selected to drop the reference voltage from 13.5 ±5% vdc to 10.000 vdc. Failure of these components is extremely remote. It is recommended that the instrument be returned to the factory if a problem is suspected.

** (B) The resistors forming the Kelvin-Varley decks are factory matched to achieve an overall accuracy better than ±.005% absolute. When ordering, include instrument model and serial number.

*** (C) R64 is matched to the balance of the Kelvin-Varley divider by means of R63. R63 is factory selected and may vary in value from instrument to instrument.

WARRANTY

ELECTRO INSTRUMENTS, INC. warrants each product of its manufacture to be free from defects in material and workmanship for a period of one year after delivery to the original purchaser. In equipment utilizing major vendor items, such as paper tape punches, printer mechanisms, vacuum tubes or crossbar switches, the vendor's warranty will apply. Liability under this warranty consists solely of servicing, adjusting, and/or the replacement of defective parts on any product returned to ELECTRO INSTRUMENTS, INC. for this purpose with transportation charges prepaid. Permission from ELECTRO INSTRUMENTS, INC. or their authorized representative must be obtained before any product may be returned for any reason. Service or shipping information will be supplied upon notification of the difficulty encountered and the model and serial number of the instrument in question. This warranty is void under any of the following conditions:

In products using stepper switches, if these switches are not lubricated or cleaned as specified.

Product stored or operated under ambient conditions other than those specified.

Unauthorized modification of product.

Damage incurred under other than normal operating and/or maintenance conditions.

ELECTRO INSTRUMENTS, INC.